

REMARKS

The Office Action dated August 8, 2006, has been received and carefully noted. The above amendments to the claims, and the following remarks, are submitted as a full and complete response thereto.

Claims 1 and 8 have been amended to more particularly point out and distinctly claim the subject matter which is the invention. No new matter has been added, and no new issues are raised which require further consideration and/or search. Claims 1-15 are submitted for consideration.

Claims 1, 4 and 5 were rejected under 35 U.S.C. 103(a) as being anticipated by U.S. Patent No. 5,476,685 to Rocher in view of U.S. Patent No. 6,506,483 to Fehrenbacher. Claims 8, 9 and 11-15 were rejected under 35 U.S.C. 103(a) as being unpatentable over Rocher. According to the Office Action, Rocher teaches or suggests all of the elements of claims 8, 9 and 11-15 except for teaching that its fibers are stable. Therefore, the Office Action combined Rocher and Fehrenbacher to yield all of the elements of claims 1, 4, 5, 8, 9 and 11-15. The rejections are traversed as being based on references that neither teach nor suggest the novel combination of features clearly recited in independent claims 1 and 8.

Claim 1, upon which claims 2-7 depend, recites a ceramic matrix composite material which includes non-oxide dimensionally-stable ceramic fibers, which are formed in a complex fiber architecture by conventional textile processes. The matrix composite material also includes a thin mechanically weak interphase material, which is coated on

the fibers and a non-oxide or oxide ceramic matrix, which is formed within the interstices of the interphase-coated fiber architecture. During a final step of composite fabrication or post treatment at a high temperature, the interphase is allowed to debond from the matrix while still adhering to the fibers, thereby providing enhanced oxidative durability and damage tolerance to the fibers and the composite material. Fiber debonding is induced after matrix consolidation via heat treatments of thermally induced stress states that act on the fiber interphase on cool down.

Claim 8, upon which claims 9-15 depend, recites a method of forming a ceramic matrix composite including selecting chemical compositions for non-oxide fibers, a thin and mechanically weak interphase material, and a non-oxide or oxide matrix. The method also includes forming the non-oxide dimensionally-stable fibers into complex architectures and depositing the thin and mechanically weak interphase material on the non-oxide fibers. The method further includes depositing the non-oxide or oxide matrix on the interphase material and processing the non-oxide fibers, the interphase material, and the non-oxide or oxide matrix such that, after a final composite processing, debonding or mechanical decoupling is already achieved between the interphase material and the non-oxide or oxide matrix. Fiber debonding is induced after matrix consolidation via heat treatments of thermally induced stress states that act on the fiber interphase on cool down.

As will be discussed below, the cited prior art references of Rocher and Fehrenbacher fail to disclose or suggest the elements of any of the presently pending claims.

Rocher discloses that carbon fibers are used to form reinforcement textures in thermo-structural ceramic matrix composite materials. The materials have properties that make them particularly apt to withstand large mechanical stresses at high temperatures. They are composed of a ceramic matrix deposited within the porous structure of a fibrous reinforcement. Specifically, the fibrous reinforcement made of carbon is used to construct a pre-form of a work piece to be manufactured. The fibrous reinforcement is then densified by the matrix material. This densification can be achieved by liquid phase impregnation using a matrix precursor, followed by a thermal treatment leaving behind a deposit of matrix materials on the fibers within the reinforcement. Several impregnation cycles are generally necessary to obtain the required degree of densification. Densification can also be obtained by chemical vapor infiltration inside an infiltration furnace. See Col. 1, lines 19-41.

Rocher also teaches that the aim of the invention is achieved by submitting the carbon fiber reinforcement material, prior to densification by the matrix, to a thermal treatment in a non-oxidizing environment at a temperature greater than 1300° C. and less than 2200° C. Such a thermal treatment makes it possible to obtain a composite material having improved mechanical strength, in particular better tensile and creep strength. The mechanical strength of the composite material is improved by performing a heat

treatment of the carbon fiber reinforcement in a non-oxidizing environment. The heat treatment is carried out on the carbon fiber reinforcement either before or after making the fibrous reinforcement perform, but always before deposition of the ceramic matrix material. Col. 1, line 59-Col. 2, line 14.

Fehrenbacher discloses that fiber reinforced ceramic matrix composites depend on a fiber/matrix interface coating that is capable of transmitting load from the matrix to the fibers as well as deflecting or blunting matrix cracks. The crack deflection capabilities are attributed to the interfacial slip or debonding of the interfacial coating from the fiber. The strength of the fiber debond coating to the fiber must be strong enough to transmit the matrix load but weak enough to debond from the fiber once cracks begin to propagate to the interface coating. Debond coatings must adhere to the underlying reinforcing fiber with enough strength to permit the fiber to provide its reinforcing function, while being able to “debond” from the fiber and allow relative movement between the fiber and the coating during a stress event. Col. 1, lines 1-40.

Applicants submit that the combination of Rocher and Fehrenbacher simply does not teach or suggest each of the elements recited in the pending claims. Claims 1 and 8 recite, in part, fiber debonding is induced after matrix consolidation via heat treatments of thermally induced stress states that act on the fiber interphase on cool down. Rocher describes heat treatments to carbon fibers pre-forms and in one case heat treatment of interface-coated fiber pre-forms. In Rocher, the heat treatments do possibly shrink the fibers resulting in fiber-stabilization and they may alter the fiber surface to promote weak

interfaces between the fibers and the matrix. According to Rocher, all of the above is performed **prior** to the deposition of the matrix. In the present invention, on the other hand, fiber-debonding is induced **after** matrix consolidation via heat treatment or thermally induced stress-states that act on the fiber interphase/matrix interface on cool down.

In the present invention, as recited in the pending claims, the ceramic matrix composite material includes non-oxide dimensionally-stable ceramic fibers. Thus, there is no alteration to the fibers as the present invention requires already stable fibers. The present invention, as recited in claims 1 and 8, recites a method of final fabrication or post treatment at sufficiently high temperatures of a non-oxide matrix composite system reinforced by micro-structurally and dimensionally stable non-oxide fibers in order to in-situ shrink a dimensionally unstable fiber coating onto the fiber and away from the matrix. The present invention, as recited in claims 1 and 8, also recites a method of pre-selecting the constituents of a non-oxide or oxide matrix composite system reinforced by micro-structurally and dimensionally stable non-oxide fibers in order to develop tensile residual stresses between fiber coating and matrix during cool down from the final matrix fabrication temperature. Therefore, Applicants respectfully asserts that the rejection under 35 U.S.C. §103(a) should be withdrawn because neither Rocher nor Fehrenbacher, whether taken singly or combined teaches or suggests each feature of claims 1 and 8 and hence, dependent claims 4, 5, 9 and 11-15 thereon.

Claims 2, 3, 6 and 7 were rejected under 35 U.S.C. 103(a) as being unpatentable over Rocher in view of U.S. Patent No. 5,945,166 to Singh and Fehrenbacher. Claim 10 was also rejected under 35 U.S.C. 103(a) as being unpatentable over Rocher in view of Singh. According to the Office Action, Rocher and Fehrenbacher teaches all of the elements of claims 2, 3, 6, 7 and 10 except for teaching such treatment to manipulate stress in the matrix and further shrink the product. Thus, the Office Action combined the teachings of Rocher, Fehrenbacher and Singh to yield all of the elements of claims 2, 3, 6, 7 and 10. The rejection is traversed as being based on references that neither teach nor suggest the novel combination of features clearly recited in independent claims 1 and 8, upon which claims 2, 3, 6, 7 and 10 depend.

Singh discloses manipulation of residual stress states in order to fabricate “zones” or layers of compressive/tensile residual stress states to accommodate tensile/compressive thermally induced stresses during the service of a part. These are macro stresses formed in the outer surfaces of the composite itself.

As noted above, claims 2, 3, 6, 7 and 10 depend on claims 1 and 8. Singh does not cure any of the deficiencies of Rocher and Fehrenbacher with respect to claims 1 and 8, as described above. Specifically, Singh does not teach or suggest wherein fiber debonding is induced after matrix consolidation via heat treatments of thermally induced stress states that act on the fiber interphase on cool down, as recited in claims 1 and 8. Therefore, Applicant respectfully asserts that the rejection under 35 U.S.C. §103(a) should be withdrawn because neither Rocher nor Singh, whether taken singly or

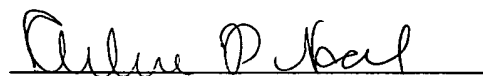
combined, teaches or suggests each feature of claims 1 and 8 and hence, dependent claims 2, 3, 6, 7 and 10 thereon.

As noted previously, claims 1-15 recite subject matter which is neither disclosed nor suggested in the prior art references cited in the Office Action. It is therefore respectfully requested that all of claims 1-15 be allowed and this application passed to issue.

If for any reason the Examiner determines that the application is not now in condition for allowance, it is respectfully requested that the Examiner contact, by telephone, the applicant's undersigned attorney at the indicated telephone number to arrange for an interview to expedite the disposition of this application.

In the event this paper is not being timely filed, the applicant respectfully petitions for an appropriate extension of time. Any fees for such an extension together with any additional fees may be charged to Counsel's Deposit Account 50-2222.

Respectfully submitted,


Arlene P. Neal
Registration No. 43,828

Customer No. 32294
SQUIRE, SANDERS & DEMPSEY LLP
14TH Floor
8000 Towers Crescent Drive
Tysons Corner, Virginia 22182-2700
Telephone: 703-720-7800
Fax: 703-720-7802
APN:kmp